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Final report of the shipboard tests of the RWO Ballast Water Treatment System CleanBallast for Type Approval according to Regulation D-2 and the relevant IMO Guideline (G8)

(March 2009 - January 2010)

Shipboard tests onboard MV Maersk Penang

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S. Gollasch 2010-03-02

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1. Introduction

The five shipboard tests to test the CleanBallast ballast water treatment system, developed by RWO, Bremen, Germany, were undertaken on four voyages of the container vessel Maersk Penang between March 2009 and January 2010. The vessel details are outlined in the Table 1.

Table 1. Main dimensions of the test vessel and tank details.

Vessel name	Maersk Penang
IMO number	9168192
Vessel type	Container
Length overall	210.0 m
Dead Weight Tonnage (DWT)	37842 t
Container capacity	2890 TEU
Total ballast water capacity	10444 m³
Number of ballast tanks	25
Number of ballast pumps	2
Capacity of ballast pumps	600 t/h
Number of ballast water	1
treatment systems installed	
Capacity of ballast water	500 m³/h
treatment system	
Control tank	2WHP,
	Upper side tank, starboard
Control tank capacity	855.1 m ³
Treated tank	2WHS,
	Upper side tank, portside
Treated tank capacity	797.5 m ³

The test ship was operated on the route Bremerhaven – Rotterdam – Montreal and one voyage usually stretched over ca. 3 weeks. During the last voyage the route was changed to Bremerhaven – Rotterdam – Antwerp – Le Havre – Montreal which usually takes ca. 3.5 weeks.

Both tanks identified for the tests, i.e. the control and treated tanks, are indicated in Table 1.

The following paragraphs give a general description of the ballast water management approach onboard the MV "Maersk Penang". In 1997; when this ship was built, no automatic ballast water management system was planned.

The chief officer receives a disc with all data and information about the cargo operations. After measuring the density of the seawater with a density meter these data are filled into the load-master computer program. The software calculates the ships

stability and structural stresses. The heeling of the ship is controlled by an anti-heeling system during the cargo operations.

With this information the chief officer decides which ballast water tank(s) have to be filled or emptied to compensate unequal cargo distribution, to provide for adequate vessels stability, trim, heeling and stresses. It is also possible to transfer ballast water from tank to tank, to reduce ballast uptake operations.

Onboard a ballast log report is filled out which indicates the ballast operation in detail for one tank. For every ballast tank a log report is foreseen.

The installed CleanBallast System had a capacity to match the capacity of the vessel's ballast water pumps. The treatment system was installed at the bottom of a cargo bay in a uniquely designed 40 foot container. The CleanBallast System was fully implemented and integrated into the ballast system of the vessel, but the system was only operated during the tests performed.

During the test runs both ballast water tanks, the control tank and the treated tank, were filled in parallel and emptied in sequence. The stability of container ships like the test ship did allow only for ballast water operations in accordance with the cargo conditions. This may include the partly filling and/or emptying of ballast water tanks. However, all test runs were undertaken by emptying and filling the tanks as much as possible. Prior to each test run both tanks were washed by undertaking at least a one time ballast water exchange.

All samples were taken during almost the entire ballast water uptake and discharge time. This likely resulted in a more accurate measurement of organism densities compared to just taking sub-samples during parts of the ballast water pumping operation.

During the first three voyages the intake experiments were undertaken off Texel Island and the discharge experiments at anchorage near Rotterdam. On the last voyage two test runs were performed, one as before with a ballast water intake off Texel Island and a discharge at Rotterdam anchorage followed by a second test run with an intake near Antwerp and a discharge near Le Havre.

During all tests runs samples were taken by sampling team members of GoConsult, Hamburg, Germany.

2. Sampling scenario

During each test run samples were collected by using multiple HydroBios ballast water sampling kits in parallel and the samples were processed onboard as much as possible and as outlined in the onboard sampling protocol (Gollasch 2009). Plankton organisms larger than 50 micron in minimum dimension, *E. coli* and *Enterococci* were analysed onboard directly after sampling. Cholera bacteriae samples were prepared onboard for later analysis by IBEN, Bremerhaven. The samples for plankton above 10 micron and below 50 micron in minimum dimension were analysed by NIOZ, Texel, the Netherlands. Procedures were followed according to the test protocol (Gollasch 2009, see also Appendix 1) which was prepared in line with the most up-to-date version of the IMO Guideline G8 *Guidelines for the Approval of Ballast Water Management Systems* (IMO G8 2008).

The required number of samples and their volumes for one test cycle according to G8 are given in Table 2. According to G8 during uptake the control water line was sampled.

Table 2. Number of	of samples	and their volumes	for one test	cycle according to G8.

Sample	Treated tank	Contro	ol tank
purpose	discharge	uptake	discharge
	(para 2.2.2.6.2	(para 2.2.2.6.1,	(para 2.2.2.6.1
	and 2.2.2.6.3)	2.2.2.6.3 and	and 2.2.2.6.3)
		2.2.2.9)	
Environmental	1 sample	1 sample	1 sample
parameters ¹	(not required in		(not required in
	G8)		G8)
>50 µm ²	3 x >1000 L	1 x >1000 L	1 x >1000 L
<50 to >10 µm	3 x >1 L	1 x >1 L	1 x >1 L
Bacteriae	3 x >500 ml	1 x >500 ml	1 x >500 ml
			(not required in
			G8)

The following samples were taken and processed in addition to the requirements of G8:

- Analysis of environmental parameters of the discharged treated water;
- Analysis of environmental parameters of the discharged control water:
- Analysis of bacteriae of the discharged control water; and
- Analysis of organisms below 10 micron.

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¹ Temperature, salinity, total suspended solids and particulate organic carbon, see G8, Annex, Part 2, paragraph 2.2.2.9

² There is an inconsistency and unclear wording in G8 regarding the uptake sample of the treated line. G8, Annex, Part 2, paragraph 2.2.2.5 *Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration...* but 2.2.2.6 *Sampling regime* sets only requirements for the discharge of treated water. To be on the save side samples during uptake of the treated water are therefore recommended.

3. Results

The following tables show the results regarding environmental parameters and biological analysis of the samples of all five test runs. It should be noted that more samples as required by G8 were taken and processed during all test runs (see above).

Environmental parameters

The sample processing revealed environmental parameters as expected in the ballast water uptake region off Texel Island and off Antwerp.

Biological results

The results show that the CleanBallast ballast water treatment system complied with the standards in Regulation D-2 for all tested groups during all tests of the treated water upon discharge.

The minimum intake concentrations of organisms for valid tests according to G8 were met in the first three test runs. During the last two test runs the G8 intake organism density for organisms above 50 micron in minimum dimension were met. However, the minimum intake concentration of the organisms below 50 micron and above 10 micron in minimum dimension could not be met due to the seasonal low density of such organisms in the ballast water uptake area (see below, Test Cycle Report, Test Runs 4 and 5). During these last two tests all organism groups, including the organisms below 10 micron, met the D-2 standard at discharge.

Test Cycle Report, Test Run 1

Date and time for ballast water **uptake**: 28.03.2009, 14:15 to 15:10

- Position of ship during ballast water uptake ca. 53°09,0N / 004°22,0E to 52°56,0N / 003°59,0E.
- Distance travelled during uptake was ca. 18 nm.
- Water depth ca. 25 to 30 m. Distance to nearest land ca. 14-26 nm.

Date and time for ballast water **discharge**: 29.03.2009, 10:32 to 13:56 (on anchorage)

• Position of ship during beginning of ballast water discharge ca. 52°04,0N / 003°50,5E.

Holding time of ballast water between uptake and discharge: approximately 20 hrs.

Table 3. Results of test run 1.

Davamatan	l lm!4	Uptake	water			Disch	arge w	ater		
Parameter	Unit	Control	IMO	Control	IMO	-	Treated	i	Aver.	IMO
		Control	IIVIO	Control	IIVIO	# 1	# 2	# 3	#1-#3	IIVIO
Temperature	ç	9.8	-	8.0	-	8.4	8.5	8.5		-
Salinity	PSU	34	-	34	-	34	34	34		-
POC **	mg/l	0.97	-	0.82	-	0.25	0.51	0.44		-
TSS **	mg/l	122	-	57	-	31	76	101		-
Sample vol. >50 µm	Litres	2259	>1000	1938	>1000	1328	1462	1418		>1000
Organisms >50µm	org./1m³	1018	>90	454	>10	0	0	0	0	<10
Sample vol. 50-10 µm	Litres	6	>1	5	>1	5	5	5		>1
Organisms 10-50µm*	org./1ml	170	>90	123	>10	0	0	0	0	<10
Organisms 6-7µm*	org./1ml	60	-	686	-	0	0	0	0	-
Organisms ca. 4 µm*	org./1ml	70	-	1006	-	0	0	0	0	-
Sample vol. bacteria	Litres	1	>0,5	1	-	1	1	1		>0,5
Sample vol. bacteria	Litres	3	>0.5	3	-	3	4	4		>0.5
Escherichia coli	cfu/100ml	0	-	0	-	0	0	0	0	<250
Intestinal Enterococci	cfu/100ml	73.3	-	51.6	-	2.3	1.8	0.0	1.4	<100
Vibrio cholerae**	cfu/100ml	0	-	0	-	0	0	0	0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Please note that the higher number of organisms below 10 micron in the control discharge compared to the control intake indicates that organisms remained in the tank from previous tank fillings.

Test Cycle Report, Test Run 2

Date and time for ballast water uptake: 18.04.2009, 11:00 to 11:55

- Position of ship during ballast water uptake ca. 53°51,0N / 006°28.8E to 53°45,2N / 005°57,7E.
- Distance travelled during uptake was ca. 17 nm.
- Water depth ca. 26 m. Distance to nearest land ca. 13 nm.

Date and time for ballast water **discharge**: 19.04.2009, 09:53 to 11:39 (on anchorage)

 Position of ship during beginning of ballast water discharge ca. 52°07,0N / 003°47,0E.

Holding time of ballast water between uptake and discharge: approximately 23 hrs.

Table 4. Results of test run 2.

Danamatan	11!1	Uptake	water			Disch	arge wa	ater		
Parameter	Unit	Control	IMO	Control	IMO		Treated		Aver.	IMO
		Control	IMO	Control	IMO	# 1	# 2	# 3	#1-#3	
Temperature	°C	9.4	-	10.4	-	10.4	10.4	10.4		-
Salinity	PSU	33	-	34	-	33	34	34		-
POC **	mg/l	2.70	-	0.87	-	1.31	0.32	0.26		-
TSS **	mg/l	175	-	177	-	177	180	175		-
Sample vol. >50 µm	Litres	2241	>1000	1973	>1000	1103	1249	1173		>1000
Organisms >50µm	org./1m³	692	>90	490	>10	0	0	0	0.0	<10
Sample vol. 50-10 µm	Litres	6	>1	6	>1	6	6	6		>1
Organisms 10-50µm*	org./1ml	960	>90	260	>10	0	0	0	0.0	<10
Organisms 6-7µm*	org./1ml	618	-	331	-	0	0	0	0	-
Organisms ca. 4 µm*	org./1ml	1961	-	1687	-	0	0	0	0	-
Sample vol. bacteria	Litres	1	>0.5	1	-	1	1	1		>0.5
Escherichia coli	cfu/100ml	0	-	0	-	0	0	0	0.0	<250
Intestinal Enterococci	cfu/100ml	0	-	0	-	0	1	1	0.7	<100
Vibrio cholerae**	cfu/100ml	0	-	0	-	0	0	0	0.0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Test Cycle Report. Test Run 3

Date and time for ballast water uptake: 01.08.2009, 18:14 to 19:04

- Position of ship during ballast water uptake ca. 53°52N / 006°20E to 53°48N / 006°10E.
- Distance travelled during uptake was ca. 10.5 nm.
- Water depth ca. 24 m. Distance to nearest land ca. 15 to 17.5 nm.

Date and time for ballast water **discharge**: 02.08.2009, 13:50 to 14:34 (on anchorage)

 Position of ship during beginning of ballast water discharge ca. 52°80N / 003°52E.

Holding time of ballast water between uptake and discharge: approximately 17 hrs.

Table 5. Results of test run 3.

Dorometer	l lmit	Uptake	water			Disch	arge w	ater		
Parameter	Unit	Control	IMO	Control	IMO	-	Treated	t	Aver.	IMO
		Control	IIVIO	Control	IIVIO	# 1	# 2	# 3	#1-#3	IIVIO
Temperature	°C	19.7	1	19.8	1	19.2	19.2	19.2		-
Salinity	PSU	33	-	33	-	33	33	33		-
POC **	mg/l	0.53	1	0.32	1	0.52	0.23	0.25		-
TSS **	mg/l	5	1	8	1	8	7	5		-
Sample vol. >50 µm	Litres	1422	>1000	2003	>1000	1412	1399	1411		>1000
Organisms >50µm	org./1m³	1378	>90	1014	>10	0	5.7	5.7	3.8	<10
Sample vol. 50-10	Litres	6	>1	6	>1	6	6	6		>1
μm	Litios	0		0		U	U	U		
Organisms 10-50µm*	org./1ml	645	>90	1270	>10	0	0	0	0.0	<10
Organisms 6-7µm*	org./1ml	1597	-	2904	-	0	0	0	0	-
Organisms ca. 4 µm*	org./1ml	2453	-	3755	-	0	0	0	0	-
Sample vol. bacteria	Litres	1	>0.5	1	-	1	1	1		>0.5
Escherichia coli	cfu/100ml	0	-	0	-	0	0	0	0.0	<250
Intestinal Enterococci	cfu/100ml	0	-	0	-	0	0	0	0.0	<100
Vibrio cholerae**	cfu/100ml	0	-	0	-	0	0	0	0.0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Please note that the higher number of organisms below 50 micron in the control discharge compared to the control intake indicates that organisms remained in the tank from previous tank fillings.

Test Cycle Report. Test Run 4

Date and time for ballast water <u>uptake</u>: 24.01.2010, 07:40 to 08:34

- Position of ship during ballast water uptake ca. 53°51,7N / 004°54,7E to 53°51,7N / 004°33,7E.
- Distance travelled during uptake was ca. 12 nm.
- Water depth ca. 22 to 26 m. Distance to nearest land ca. 13.5 nm.

Date and time for ballast water discharge: 24.01.2010, 19:10 to 20:40

• Position of ship during beginning of ballast water discharge ca. 52°48,0N / 003°58,0E.

Holding time of ballast water between uptake and discharge: approximately 12 hrs.

Table 6. Results of test run 4.

Devemeter	l lmi4	Uptake	water			Disch	arge w	ater		
Parameter	Unit	Control	IMO	Control	IMO	-	Treated	i	Aver.	IMO
		Control	IIVIO	Control	IIVIO	# 1	# 2	# 3	#1-#3	IIVIO
Temperature	°C	5.1	-	6.2	-	6.2	6.2	6.2		-
Salinity	PSU	32	-	32	-	32	32	32		-
POC **	mg/l	0.1	-	0.3	-	0.1	0.4	0.1		-
TSS **	mg/l	17	-	31	-	15	7	18		-
Sample vol. >50 µm	Litres	3138	>1000	1805	>1000	1497	1625	1464		>1000
Organisms >50µm	org./1m³	1236	>90	124	>10	0	0	0	0	<10
Sample vol. 50-10	Litres	5	>1	5	>1	5	5	5		>1
μm		· ·		· ·		Ü	Ū	Ü		
Organisms 10-50µm*	org./1ml	8	>90	13	>10	0	0	0	0	<10
Organisms 6-7µm*	org./1ml	28	-	18	-	0	0	0	0	
Organisms ca. 4 µm*	org./1ml	567	-	600	-	0	0	0	0	
Sample vol. bacteria	Litres	1	>0,5	1	-	1	1	1		>0,5
Escherichia coli	cfu/100ml	0	-	0	-	0	0	0	0	<250
Intestinal Enterococci	cfu/100ml	1	-	0	-	0	2	2	1.3	<100
Vibrio cholerae**	cfu/100ml	0	-	0	-	0	0	0	0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Test Cycle Report. Test Run 5

Date and time for ballast water **uptake**: 25.01.2010, 21:00 to 21:50

- Position of ship during ballast water uptake ca. 53°03,0N / 003°12,5E to 52°01,6N / 002°53,8E.
- Distance travelled during uptake was ca. 12 nm.
- Water depth ca. 26 to 36 m. Distance to nearest land ca. 29-33 nm.

Date and time for ballast water discharge: 27.01.2010, 08:30 to 10:15

• Position of ship during beginning of ballast water discharge ca. 50°51,5N / 001°04,3E.

Holding time of ballast water between uptake and discharge: approximately 37 hrs.

Table 7. Results of test run 5.

Donometer	l lm!4	Uptake	water			Disch	arge w	ater		
Parameter	Unit	Control	IMO	Control	IMO	-	Treated	i	Aver.	IMO
		Control	IIVIO	Control	IIVIO	# 1	# 2	# 3	#1-#3	IIVIO
Temperature	°C	6.5	-	6.5	-	6.5	6.5	6.5		-
Salinity	PSU	31	-	31	-	31	31	31		-
POC **	mg/l	0.1	ı	0.3	ı	0.1	0.3	0.2		1
TSS **	mg/l	33	-	9	-	90	68	98		-
Sample vol. >50 µm	Litres	1809	>1000	1689	>1000	1644	1654	1575		>1000
Organisms >50µm	org./1m³	785	>90	298	>10	0	0	0	0	<10
Sample vol. 50-10	Litres	5	>1	5	>1	5	5	5		>1
μm	Litios			· ·		Ü	U	· ·		
Organisms 10-50µm*	org./1ml	7	>90	4	>10	0	0	0	0	<10
Organisms 6-7µm*	org./1ml	22	1	24	1	0	0	0	0	
Organisms ca. 4 µm*	org./1ml	508	1	81	ı	0	0	0	0	
Sample vol. bacteria	Litres	1	>0,5	1	-	1	1	1		>0,5
Escherichia coli	cfu/100ml	0	-	0	-	0	0	0	0	<250
Intestinal Enterococci	cfu/100ml	2	-	8	-	1	1	1	1	<100
Vibrio cholerae**	cfu/100ml	0	-	0	-	0	0	0	0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Ballast water recording

The ballast water recording from each test, as provided by the ship owner to RWO, is given in a separate appendix to this document.

Neutralisation system and TRO concentrations

Upon request of the German Administration, the Bundesamt für Seeschifffahrt und Hydrography (BSH), this additional chapter was included in this report to provide information on the neutralisation system which is part of the CleanBallast system. The data on total residual oxidants (TRO) concentrations during shipboard type approval testing were provided by RWO and are reported in Table 8.

The CleanBallast system uses a neutralisation system to destroy TRO at deballasting which controls the TRO concentration to ensure it is always below 0.2 mg/L TRO in the system effluent, i.e. before the discharge into the environment. If a TRO concentration of 0.2 mg/L or higher is measured in the effluent of the CleanBallast system during deballasting, sodium thiosulphate solution is automatically dosed to the effluent from a storage tank via a conventional dosing pump and an injection port into the main ballast water pipe. Hereby, the dosing of sodium thiosulphate is carried out depending on the TRO concentration, which is measured upon ballast water discharge after the EctoSys[®] disinfection and before the neutralisation system. The neutralization agent dosage is proportional to the volume flow rate of the CleanBallast system. In Table 8 the TRO data at ballasting and deballasting treated water (before neutralisation) and after neutralisation by the CleanBallast system are given for all test runs during the shipboard tests.

These data prove the performance of the neutralisation system and show further that the CleanBallast system fully complies with the required maximum allowable dosage of Active Substances (TRO) of 2.5 mg/l for the ballasting of treated water at intake and 1.5 mg/l for the treatment during deballasting at discharge as well as with the maximum allowable discharge concentrations of TRO not exceeding 0.2 mg/L after neutralization during discharge (MEPC 59/2-16).

Table 8. TRO values at ballasting and deballasting treatment and after neutralisation by the CleanBallast system before discharge to the environment.

		Test	_1 28.03.09	Test_	2 19.04.09		
	Unit	Ballasting	Deballasting	Ballasting	Deballasting		
Average TRO	mg/l	1.94	0.98	Data loss 1	0.97		
After							
Neutralisation	mg/l		0.04		0.07		
		Test	_3 02.08.09	Test_	4 24.01.10	Test_5	27.01.10
		Test Ballasting	_3 02.08.09 Deballasting	T	4 24.01.10 Deballasting	Test_5: Ballasting	27.01.10 Deballasting
Average TRO	mg/l			T		_	
	mg/l	Ballasting	Deballasting	Ballasting	Deballasting	Ballasting	Deballasting

¹ PLC data loss due to power loss onboard

4. Discussion of the results

The CleanBallast System has been thoroughly tested during the four test voyages between March 2009 and January 2010 in different environmental conditions and during different seasons. During these tests the system has proven to be seaworthy and highly effective.

During all onboard tests, sample taking and sample processing was undertaken as previously outlined in the sampling protocol (Gollasch 2009, see also Appendix 1).

The surviving organisms above 50 micron in minimum dimension in the treated discharge water during test run three (i.e. 3.8 organisms per m³ which meets the D-2 standard) may have resulted from a contamination of organisms which may have become stuck in the ship's pipework. Our onboard experience is that this frequently happens and cannot be avoided as the control and treated water on this vessel in part is pumped through the same ballast water pipes. In land-based experiments this problem can easily be solved by proper pipe and tank washing which is impossible to undertake during normal ship operations at sea.

This report focuses on the organism groups as described in Regulation D-2 of the Ballast Water Management Convention (2004). However, it should be noted that also in the size class <10 micron no living phytoplankton was observed in the treated water at discharge.

5. Test validity

The D-2 Standard, as described in the IMO Ballast Water Management Convention of 2004, was met at discharge of the treated water in all five test runs. Further, the minimum water volumes of all sample types as stated in G8 were met.

However, during the last two test runs the G8 minimum intake concentration of only the organisms below 50 micron and above 10 micron in minimum dimension could not be met due to the lack of naturally occurring organisms in the time of season when the tests were undertaken

Organisms above 50 micron in minimum dimension occurred in sufficient numbers in the intake samples of all five test runs.

Consequently the first three tests are considered as valid tests according to the IMO requirements (Guideline G8 and Regulation D-2). During the last two tests the organism numbers of the size class below 50 and above 10 in minimum dimension were too low to fully meet the organism intake requirements of G8, but the organism numbers below 10 micron in minimum dimension were high during intake, but no living cells in this size

class were found during discharge indicating the efficient performance of the CleanBallast system. However, already three consecutive valid tests have been completed between March 28th and August 2nd, 2009. As G8 requires to undertake the shipboard tests during a time window not less than 6 months two additional tests were performed to finalize the testing period of six months. As stated by G8 in 2.2.2.7 "The test cycles including invalid and unsuccessful test cycles are to span a trial period of not less than six months." and in 2.2.2.8 "The applicant is requested to perform three consecutive test cycles that comply with Regulation D-2 and which are valid in accordance with paragraph 2.2.2.5. Any invalid test cycle does not affect the consecutive sequence". Consequently the success criteria for shipboard testings have been met.

References

Gollasch, S. 2009. Onboard Sampling Protocol to Test the Efficiency of the Ballast Water Treatment System developed for RWO, Bremen, Germany. Version 5, 2009-02-12. 43 pp.

IMO G8 2008. IMO Guideline G8 Guidelines for the Approval of Ballast Water Management Systems adopted on 10 October 2008 as Resolution MEPC.174(58), 28 pp.

Appendix 1 Statement regarding Ship-board Tests

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Statement regarding Shipboard-Tests of the RWO Ballast Water Treatment System CleanBallast

2010-03-01

To whom it may concern

This is to confirm that the shipboard tests of the RWO Ballast Water Treatment System CleanBallast as documented in

Final Report Shipboard Tests of the RWO Ballast Water Treatment System CleanBallast for Type Approval according to Regulation D-2 and the relevant IMO Guideline (G8) [the document this statement is appended to]

were undertaken according to the

Onboard Sampling Protocol to Test the Efficiency of the Ballast Water Treatment System developed by RWO, Bremen, Germany, Version 5, 2009-02-12.

which was evaluated and approved by the Bundesamt für Seeschifffahrt und Hydrographie, Hamburg prior to the tests.

Kind regards,

S. Gollasch

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Separate Appendix: Ballast water recording (confidential)